

Structural Engineering



4.0	TABLE OF CONTENTS		
4.1	General Approach 115 Submission Requirements		
4.2	Codes and Standards 116 Structural Design of New Buildings 116 Use of Recycled Materials		
4.3	Structural Loads		
4.4	Structural Considerations 119 Progressive Collapse 119 Floor Vibration 119 Seismic Instrumentation for Buildings 120 Geotechnical Considerations 120 Nonstructural Elements		
4.5	Alterations in Existing Buildings and Historic Structures 121 General Design Considerations for Structural Upgrading		
4.6	Seismic Requirements for Leased Buildings 122 New Construction 122 Existing Buildings		
	United States Courthouse Eugene, Oregon Architect: Morphosis GSA Project Managers: John Bland and Richard Broderick		
114	FACILITIES STANDARDS FOR THE PUBLIC BUILDINGS SERVICE		
4.0	Table of Contents		Revised March 2003 – PBS-P100

4.1 General Approach

Three characteristics distinguish GSA buildings from buildings built for the private sector: longer life span, changing occupancies, and the use of a life cycle cost approach to determine overall project cost.

GSA generally owns and operates its buildings much longer than private sector owners. Accordingly, a higher level of durability and serviceability is required for all systems. In terms of structural design, this has resulted in more stringent requirements than those stipulated in model building codes; the floor load capacity requirement of this chapter is an example.

During the life span of a typical Federal building, many minor and major alterations are necessary as the missions of Government agencies and departments change. The capability to accommodate alterations must be incorporated into the building from the outset. In some cases structural systems should be designed to provide some leeway for increase in load concentrations in the future. They should also be designed to facilitate future alterations, e.g., the cutting of openings for new vertical elements, such as piping, conduit and ductwork.

Security is an important consideration in structural design. Refer to Chapter 8: *Security Design* for design criteria related to this matter.

Submission Requirements

Every project will have unique characteristics and requirements for submission and review. The general submission requirements for each phase of project development are described in Appendix A: *Submission Requirements*.



Martin Luther King Courthouse, Newark, NJ

4.2 Codes and Standards

Codes and mandatory standards adopted by GSA for the design of all new buildings are discussed in Chapter 1.

The following FEMA Guidelines shall be incorporated into the structural design for all projects involving new and existing facilities:

- Federal Emergency Management Agency (FEMA) publications:

Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings (FEMA 350)

Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings (FEMA 351)

Recommended Post-earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings (FEMA 352)

Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications (FEMA 353).

Structural Design of New Buildings

The structural design (including wind, snow and earthquake) of new buildings, structures and portions thereof shall be in accordance with the IBC.

Use of Recycled Materials

The EPA Comprehensive Procurement Guidelines indicate the materials that must contain recycled content in the construction of buildings with federally appropriated funds. (Refer to: Chapter 1, *Recycled-Content Products*.)

Chapter 3, *Incorporation of Recycled-Content Materials* includes a listing of ASTM Specifications for cement and concrete.

Information on specifying and purchasing recycled-content products can be found on the Internet at www.epa.gov/cpg.



National Building Museum, Washington, D.C.

4.3 Structural Loads

Design loads shall be in accordance with International Building Code (IBC) except as noted:

GSA promotes flexibility in the use of space. Since corridor locations may not be known until after construction begins and are subject to change over time, use an “office” uniform live load of 3.8 kPa (80 pounds per square foot) in lieu of the tabulated uniform live load in the IBC. Spaces with higher live loads than this should be designed for the code required minimum or the actual live load, whichever is greater. Do not use live load reductions for (1) horizontal framing members, (2) transfer girders supporting columns, and (3) columns or walls supporting the top floor or roof.

Special live load requirements are specified for telecommunications equipment rooms by the EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins).

Telecommunication Closets: Use 3.8 kPa (80 pounds per square foot) minimum distributed live load capacity, which exceeds the minimum live load capacity stated in EIA/TIA Standard 569, standard part 7.2.3 of 2.4 kPa (50 pounds per square foot). Verify if any equipment will be used that exceeds this floor load requirement.

Equipment Rooms for Telecommunication Equipment: Floor loading capacity of telecommunication equipment rooms shall be sufficient to bear both the distributed and concentrated load of installed equipment. The EIA/TIA Standard 569 prescribes a minimum live load capacity for distributed loads of 12.0 kPa (250 pounds per square foot) and a minimum concentrated live load of 4.5 kN (1,000 pounds) over the area of greatest stress to be specified.



Steel bracing in the Milwaukee Courthouse

4.4 Structural Considerations

LRFD and ASD. Both Load Resistance Factor Design (LRFD) and Allowable Stress Design (ASD) are acceptable design procedures for GSA buildings. If LRFD is chosen, the design narrative must specifically address floor vibration.

Cast-in-Place Systems. Systems that have fewer limitations in cutting openings during future alterations are preferred over other systems.

Precast Systems. Precast floor framing systems should only be used for GSA office buildings when the design can be demonstrated to adapt well to future changes in locations of heavy partitions or equipment. Precast systems may be considered for low-rise structures such as parking garages, industrial buildings, and storage and maintenance facilities.

Pre-tensioning and Post-tensioning. As with precast floor framing, these systems should only be used when the design can be demonstrated to not impede future flexibility.

Base Isolation. Base isolation shall be considered for Seismic Design Categories C and D and buildings located in Regions of High Seismicity for two to fourteen story buildings, particularly on rock and firm soil sites which are stable under strong earthquake ground motion. The base isolation system must be shown to be as cost effective as conventional foundation systems. The effects of the base isolation system on the framing, mechanical, and electrical systems shall be included in the evaluation of cost effectiveness.

Passive Energy Dissipation Systems. Passive energy dissipation systems shall be considered for Seismic Design Categories C and D and buildings located in regions of moderate to high-risk seismic zones.

Innovative Mitigation Methods. Innovative mitigation methods that deviate from the requirements of FEMA 356 shall be permitted, provided an analytical procedure acceptable to GSA shows that the required performance level is attained. When new and innovative rehabilitation techniques are proposed for a specific building, a peer review panel, acceptable to GSA, shall determine the adequacy of the mitigation techniques proposed by the engineer.

Progressive Collapse

Refer to Chapter 8: *Security Design*.

Floor Vibration

The floor-framing members shall be designed with a combination of length and minimum stiffness that will not cause vibration beyond the “slightly perceptible” portion of the “Modified Reiher-Meister Scale” or an equivalent vibration perception/acceptance criteria.

Seismic Instrumentation for Buildings

For Seismic Design Categories C, D, E, F and buildings located in Regions of High Seismicity, every existing building over six stories in height with an aggregate floor area of 60,000 square feet (5574 m²) or more, and every building over 10 stories in height regardless of floor area, shall be provided with USGS approved recording accelerographs. USGS developed *guidelines* and a *guide specification* for Federal agencies for the seismic instrumentation



The W.F. Bennett Federal Building in Salt Lake City is the first federal building to use buckling-restrained brace technology.

of their buildings. The *guidelines* describe the locations and the types of instruments used for several “typical” buildings. Typical costs were also developed for existing buildings. The *Seismic Instrumentation of Buildings (with Emphasis on Federal Buildings)*, Special GSA/USGS project, USGS Project No: 0-7460-68170, can be downloaded as a PDF file at http://nsmp.wr.usgs.gov/celebi/gsa_report_instrumentation.pdf.

Geotechnical Considerations

The requirements for the geotechnical engineering investigation and report are listed in Appendix A: *Submission Requirements*.

Footings shall not project beyond property lines.

Nonstructural Elements

All nonstructural elements, components and equipment located within a building or on the site must be anchored to withstand gravity, wind, seismic, temperature, and other loads as required by IBC for new buildings and FEMA 356 for existing buildings.



Workmen on the roof of the Winder Building, Washington, D.C. install a window as part of a renovation project.

4.5 Alterations in Existing Buildings and Historic Structures

Alteration requires ingenuity and imagination. It is inherently unsuited to rigid sets of rules, since each case is unique. It is recognized that total compliance with standards may not be possible in every case. Where serious difficulties arise, creative solutions that achieve the intent of the standard are encouraged.

Where a historic structure is to be altered, special documents will be provided by GSA to help guide the design of the alterations. The most important of these is the Building Preservation Plan (BPP) which identifies zones of architectural importance, specific character-defining elements that should be preserved, and standards to be employed. For some buildings a detailed Historic Structures Report is also available. See Chapter 1: *General Requirements*.

General Design Considerations for Structural Upgrading Seismic Performance. The performance objective of a seismic upgrade is life safety, defined as the safeguarding against partial or total building collapse, obstruction of entrance or egress routes and the prevention of falling hazards in a design basis earthquake.

Not all seismic deficiencies warrant remedial action. Seismic upgrading is an expensive and often disruptive process, and it may be more cost effective to accept a marginally deficient building than to enforce full compliance with current code requirements.

Evaluation and mitigation of existing GSA buildings shall meet the requirements of ICSSC RP 6 (NISTIR 6762), *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings*, with the following modifications:

- Evaluation of existing buildings shall be in accordance with the provision of the *Handbook for the Seismic Evaluation of Buildings—A Prestandard* (FEMA 310). The primary objective of the Prestandard is to reduce the life-safety risk to occupants of Federal buildings and to the general public. **Life-Safety** is the minimum performance objective appropriate for Federal buildings.
- Seismic rehabilitation of existing buildings shall be in accordance with the provisions of *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 356). **Life-Safety** is the minimum acceptable performance level for existing Federal buildings. FEMA 356 further provides for an extended level of performance, Immediate Occupancy, where required to meet the agency’s mission. FEMA 310, *Handbook for the Seismic Evaluation of Buildings—A Prestandard*, and FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, provide the basis for defining these performance objectives, evaluation criteria and if necessary, mitigation, are identified.

If shown by FEMA 310 evaluation that the desired performance level is not satisfied, the rehabilitation of the building to attain the desired performance level shall substantially satisfy the Basis Safety Objective criteria of FEMA 356, including the use of both the BSE-1 and BSE-2 earthquake criteria.

It should be noted that the hazard level (ground motion) used in FEMA 310 to evaluate buildings is based on earthquakes with a 2% probability of exceedance in 50

years (2%/50 years). On the other hand, the hazard level used for a rehabilitation design in FEMA 356 is based on compliance with the Basic Safety Objective (BSO). The BSO requires compliance with both the BSE-2 earthquake (2%/50 years earthquake accelerations) at the Collapse Prevention Performance Level and with the BSE-1 earthquake (the lesser of the accelerations from the 10%/50 years earthquake or 2/3 of the 2%/50 years earthquake) at the Life-Safety Performance Level. The earthquake accelerations associated with the 2/3 of the 2%/50 years earthquake will result in significantly higher seismic design values than those resulting from a 10%/50 years earthquake in some areas of the country.

Upgrade Priorities. It may not be practical to upgrade an entire structure to current requirements at any one time. Whenever upgrading is only partially done, the first priority should be given to items that represent the greatest life safety risk, such as the lateral force-resisting system, unreinforced masonry bearing walls or both.

Seismic Upgrades for Historic Buildings. Historic buildings should meet the same life safety objective as other buildings. Decisions made to preserve essential historic features should not result in a lesser seismic performance than that required by ICSSC RP 6. See Chapter 1.

Seismic Strengthening Criteria for Nonstructural Elements. Where deficiencies in the attachment of elements of structures, nonstructural components and equipment pose a life safety risk, they should be prioritized and those elements with the greatest life safety risk strengthened first to meet current code requirements.

4.6 Seismic Requirements for Leased Buildings

New Construction

New buildings or the construction of an addition to an existing building shall conform to the IBC. For information see the latest edition of GSA's Solicitation for Offers (SFO).

Existing Buildings

Existing buildings shall meet the seismic requirements of the *Standards of Seismic Safety for Existing Federally Owned or Leased Building and Commentary*, ICSSC RP 6, as modified by the latest edition of GSA's Solicitation for Offers (SFO).

ICSSC RP 6 can be downloaded as a PDF at <http://fire.nist.gov/bfrlpubs/build01/PDF/b01056.pdf>.